Enterocutaneous Fistulas in the Setting of Trauma and Critical Illness

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ABSTRACT

One of the most devastating complications to develop in the general surgical patient is an enterocutaneous fistula (ECF). Critically ill patients suffering trauma, thermal injury, infected necrotizing pancreatitis, and other acute intraabdominal pathology are at unique risk for this complication as well. By using decompressive laparotomy for abdominal compartment syndrome and leaving the abdomen open temporarily for other acute processes, survival in some instances may be improved. However, the exposed viscera are at risk for fistulization in the presence of an open abdomen, a newly defined entity termed the enteroatmospheric fistula (EAF). The purpose of this article is to describe the epidemiology of ECF in the setting of trauma and critical illness, nutrition in injured/critically ill patients with ECF, pharmacologic adjuncts to decrease fistula effluent, wound care, surgical management of the EAF/ECF, and techniques for prevention of these dreaded complications in patients with an open abdomen.

KEYWORDS: Enterocutaneous and enteroatmospheric fistula, trauma, open abdomen, temporary abdominal closure

Objectives: On completion of this article the reader should be able to summarize the epidemiology of enterocutaneous fistulas in the setting of trauma and critical illness as well as manage the critically ill/injured patient with an open abdomen with techniques to optimize fistula prevention.

Enterocutaneous fistulas (ECF) are one of the most devastating abdominal complications described in the practice of surgery. ECF can arise as a complication of injury, intraabdominal surgery, malignancy, inflammatory bowel disease, postradiation therapy for malignancy, or as a result of distal obstruction. Traumatically injured and critically ill patients are presented with unique risks for ECF, specifically as a result of intentional or nonintentional bowel injury, intraabdominal infections, and after laparotomy for decompression of abdominal compartment syndrome (ACS). A newly defined complication that is almost exclusively diagnosed in these patients is the enteroatmospheric fistula (EAF).[1] This type of fistula arises in the setting of an open abdomen with exposed viscera. The purpose of this article is to provide a detailed description of EAF/ECF that develop in the subsets of patients traumatically injured, after thermal injury, and other acute intraabdominal processes that are prone to require a period of time with an open abdomen and exposed alimentary tract.

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EPIDEMIOLOGY AND RISK FACTORS FOR ECF IN TRAUMA AND CRITICAL ILLNESS

ECF is an uncommon and not well studied posttraumatic complication. The occurrence of posttraumatic ECF, however, is known to be associated with considerable morbidity. Although the true incidence of this adverse event is unknown, one large study of 2373 patients requiring trauma laparotomy conducted by Teixeira and colleagues identified ECF development in 1.5%.[1] This group found that the development of posttraumatic ECF was associated with significant increase in intensive care unity (ICU) length of stay (28.5 ± 30.5 vs 7.6 ± 9.3 days, $p = 0.004$), hospital length of stay (82.1 ± 100.8 vs 16.2 ± 17.3 days, $p < 0.001$) and mean hospital charges ($539,309 vs $126,996, $p < 0.001$).

Since the introduction of damage control principles for abdominal trauma, open abdominal management has become an increasingly common component of trauma care.[2] The open abdomen may represent particular increased risk for the development of ECF, also referred to as EAF when occurring in this setting (Fig. 1). Several groups have examined this topic, identifying an EAF rate of between 4.5% and 25% following open abdominal management.[3 7]

The risk factors for the development of posttraumatic EAF/ECF are likely multiple. In the aforementioned examination by Teixeira and colleagues, 89% of patients who developed an ECF had an antecedent hollow viscus injury repair; with 56% having multiple hollow viscus injuries.[1] The findings of this group also suggested that location of the viscus injury may prove important, with the majority of ECF in these patients arising from colonic sources. To date, however, the location and number of anastomoses have not been clearly defined as independent risk factors for EAF/ECF development in well-designed studies.

The method of anastomosis following resection of injured bowel has also not proven to play a significant role in the occurrence of EAF/ECF after trauma. In a study conducted by Kirkpatrick and colleagues, of 232 patients with full-thickness bowel injuries requiring surgical intervention, the choice of stapled or hand-sewn repair did not prove an independent predictor of subsequent ECF development.[7] This group found that only the need for damage control procedures and associated pancreaticoduodenal injuries were statistically significant predictors of ECF development. In another study of 297 patients with penetrating colon injuries conducted by Demetriades and the members of an American Association for the Surgery of Trauma prospective multicenter study group, the investigators found that the choice of stapled or hand-sewn anastomosis did not affect the incidence of anastomotic complications, including leak or fistula development.[8] In a separate report from the same group, they found that the use of colonic diversion over primary anastomosis following penetrating colonic injury also failed to prove protective in avoiding abdominal septic complications, including abscess and fistula.[9]

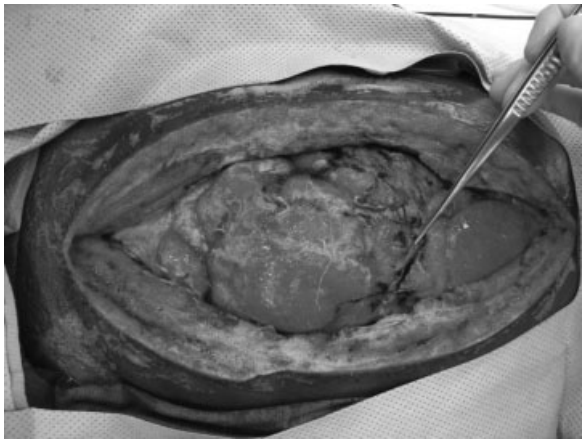

Figure 1 Enteroatmospheric fistula: forceps point to proximal small bowel fistula in the upper abdomen.

ECF can also complicate the care of thermally injured patients. ECF as a result of direct thermal injury to bowel has been described most commonly in the setting of electrical injury.[10 12] Fistulas have also been attributed to direct injury to the bowel wall located deep to full-thickness abdominal wall burns, burn resuscitation-associated hypotension-induced hollow viscous perforation, and high-voltage related small bowel perforation.[13 16] More commonly, laparotomy for abdominal compartment syndrome leaves the underlying alimentary tract exposed and at risk for the development of EAF as a result of bowel wall edema, serosal injury, and frequent manipulation during temporary abdominal closure dressing changes. ACS in thermal injury has a mortality of 100% when left untreated and 60% when patients undergo abdominal decompression.[17] Large fluid resuscitation volumes and full-thickness abdominal eschar contribute to the development of ACS in these patients. The addition of the open abdominal wound to the patient's overall burden leads to worse fluid and electrolyte losses, protein losses, the risk of EAF/ECF, and the need for a major abdominal wall reconstructive procedure.[18]

The operative management of infected pancreatic necrosis (IPN) includes laparotomy and necrosectomy. Some authors advocate the technique of open packing with serial pancreatic débridements for the management of IPN.[19] Laparostomy and lesser sac marsupialization allow for serial debridement of the pancreas as well.[20] The exposed hollow viscous is at risk for EAF development due to alimentary tract exposure with multiple manipulations during repeat necrosectomies or débridements. ECF can also develop as an extension of the lesser sac inflammation through the leaves of the transverse mesocolon leading to direct involvement of the colon or thrombosis of adjacent mesenteric vessels and infarction

of the colon.[21] As noted by Russell and colleagues, the retroperitoneal inflammation may spread to involve any segment of small or large bowel, not just the transverse colon. The incidence of ECF in series evaluating the operative treatment of IPN ranges from 4% to 31%.[22 24]

Bacterial peritonitis mortality continues to be an astounding 30%, a value stable for the past 70 years.[25] The reason mortality has not seen a significant decrease in intraabdominal infections is thought to be due to failure to control the initial infection with persistence of peritonitis. Newer techniques have evolved in the attempt to improve on this mortality including continuous peritoneal lavage and open packing of the abdomen with planned reexploration, yet the rate of ECF continues to be widely varying.[26] Duff and Moffat reported a 28% ECF rate in patients with peritonitis managed with an open abdomen.[27] In separate reviews of open abdomen management for peritonitis, Bosscha reported an ECF rate of 24% ($n = 16/67$) and Schein 79% ($n = 41/52$).[28,29]

Massive fluid resuscitation during the perioperative management of ruptured abdominal aortic aneurysm leads to increased intraperitoneal and retroperitoneal volume, visceral edema, abdominal wall edema, and may lead to ACS. The term abdominal compartment syndrome was actually coined by Kron et al after observing physiologic improvements after decompressive laparotomy in three of four patients that had developed oliguria and abdominal distention after abdominal aortic aneurysm repair.[30] The advent of endovascular techniques for the management of RAAA has not eliminated the risk of ACS. Mayer et al demonstrated in 102 patients undergoing endovascular repair (eVAR) for RAAA that 20 went on to develop ACS.[31] There may be a benefit in preemptively leaving the abdomen open after RAA repair in patients at high risk for the development of ACS. A physiologic and survival benefit was demonstrated in Oelschlager and colleague's retrospective review of delayed abdominal closure after open RAAA treatment compared with primary fascial closure.[32] Although the delayed abdominal closure group showed a trend toward improved survival, oxygenation, and frequency of late death due to multiorgan failure, one patient developed an ECF postoperatively compared with none in the primary closure group. These reports highlight the fact that after management of RAAA, patients frequently require cautious management of an open abdomen with the alimentary tract at risk for the development of EAF. In addition, hindgut ischemic complications may develop after emergent aortic surgery with the resultant risk of ECF as well.

Although an uncommon procedure performed only at highly specialized centers, intestinal transplantation (ITX) is not without abdominal complications to include the development of ECF. In Zanfi et al's series of 15 cases of ITX with abdominal walls deemed difficult to close, two patients suffered an ECF, one being fatal.[33] Both ECF developed in the group of four patients whose abdominal walls were managed with fascial closure using prosthetic mesh.

FISTULA PREVENTION IN THE MANAGEMENT OF THE OPEN ABDOMEN

Several care issues specific to open abdominal management have been explored as risk factors for EAF development. The use of early enteral feeding for patients undergoing open abdominal management, in particular, has been contested. In a study conducted by Collier and colleagues of patients with open abdomens for greater than 4 days, investigators found that early enteral nutrition (≤ 4 days) actually resulted in a lower fistula formation rate than nutritional approaches that utilized later initiation of enteral feedings (9% vs 26%, respectively).[34] This group also noted that the use of early enteral nutrition resulted in earlier primary abdominal closure and lower hospital charges. This study was, however, limited by its small sample size and retrospective design.

Paramount in the management of the patient with the open abdomen is the prevention of EAF. Preventative techniques include coverage of hollow viscera with omentum or another nonadherent protective barrier, avoidance of hyperresuscitation and resultant bowel edema, avoidance of serosal injury, and expedient fascial or skin closure.[35] The method of temporary abdominal closure and its association with the development of EAF/ECF has also been evaluated in each disease process noted above as well as in a large, systematic review. Keramati described the technique of Wittmann patch-assisted (Wittmann patch; Starsurgical, Burlington, WI) delayed primary fascial closure for the management of the open abdomen after decompression for ACS in six burned patients.[36] All abdominal fascial defects were successfully closed and no ECF occurred.

In regards to patients treated for IPN, a direct comparison of the techniques of debridement followed by open packing versus closure over drains did not result in a significant difference in the rate of the development of ECF.[19] An evaluation of gastrointestinal complications of severe acute pancreatitis by Ho and colleagues identified necrosis and infection but not open packing technique as factors that increased the risk of ECF.[37] Tsiotos, Smith, and Sarr evaluated the incidence and outcome of ECF and pancreatic fistulas developing at their institution after surgical management of severe necrotizing pancreatitis.[24] Of 61 patients, four fistulas were identified at initial laparotomy for necrosectomy and 19 developed ECF between 4 and 60 days of initial operation. The mortality rate with ECF development was 24% and was not significantly different from the mortality associated with pancreatitis.

Tremblay and colleague's review of various techniques of open abdominal management for various

disease processes at Grady Memorial Hospital in Atlanta included 16 patients with intraabdominal sepsis (IAS).[38] The initial open abdomen closure technique included skin towel clip closure in seven, plastic sheet silo (Bogota bag) in two, and polyglactin mesh closure in seven. Five IAS patients developed ECF and had an associated mortality of 40%. The authors found no association between type of open abdomen management and the development of ECF. Adkins conducted a retrospective review of the open management of patients with IAS.[26] Open abdomen patient data was compared with a control group diagnosed with severe IAS with primary fascial closure. The open abdomen group had a fistula rate of 14.8% ($n = 12/81$). No mention of fistulas developing in the primary fascial closure group was made.

The management of the open abdomen after RAAA repair in terms of the development of EAF/ECF has not been well studied. Ciresi et al described the use of Goretex (W.L. Gore and Associates, Flagstaff, AZ) mesh temporary abdominal closure for the management of the open abdomen in nine patients after RAAA repair considered to be at high-risk for the development of ACS.[39] These nine patients were studied contemporaneously with a group of nine trauma patients with open abdominal wounds after damage control laparotomy ($n = 6$) and decompression for ACS ($n = 3$). All RAAA patients achieved delayed fascial closure whereas only 63% of trauma patients were closed. A single fistula developed in the trauma group. The use of the Goretex, nonabsorbable mesh was noted by the authors to decrease the burden of the large open abdominal wound and minimizes the risk of ECF development compared with other techniques. In their review of ACS after RAAA management, Loftus and colleagues advocated the use of the Wittmann Patch closure device for temporary abdominal closure (TAC) as it allows for successive tightening and delayed fascial closure.[40] The authors state that the Velcro mesh is advantageous to a single- layer mesh due to a theoretical decreased risk of the development of ECF in patients treated for RAAA.

Zanfi et al's series of ITX patients reported that all four prosthetic mesh implants were complicated by infection and two patients developed an ECF as noted above.[33] The authors recommended that difficult abdominal wall closure after ITX be managed with abdominal wall transplantation and avoidance of mesh implantation.

A recent systematic review of the technique of TAC was published with the goal of reporting the method associated with the highest fascial closure rate and lowest mortality.[41] In addition, the authors determined the rate of ECF development for individual TAC management techniques. Fifty-one articles including 3169 patients were reviewed. TAC methods included the V.A.C. system (Kinetic Concepts, Inc., San Antonio, TX), a vacuum pack, an artificial burr (Wittman Patch), dynamic retention sutures (DRS), a plastic silo (Bogota bag), an absorbable or nonabsorbable mesh or sheet, loose packing with standard gauze, skin approximation, and a zipper. The highest fascial closure rate and lowest mortality rate were in the V.A.C. system and artificial burr methods. The loose-packing technique was associated with the highest fistula rate (28%), followed by the zipper (13.8%), vacuum pack (5.7%), mesh/sheet (5.5%), V.A.C. (2.9%), artificial burr (2%), and silo (0%). The studies evaluating dynamic retention sutures and skin only did not report the complication of ECF. The authors' discussion of EAF/ECF and TAC technique stated that factors other than technique may contribute to the development of EAF and that the risk of EAF development may have directed the TAC technique decision in the individual reports making direct conclusions difficult to draw.

The use of the V.A.C. system for TAC management has undergone specific scrutiny as a potential contributor to the development of EAF/ECF in the patients with an open abdomen. In a study conducted by Bee and colleagues, investigators conducted a prospective randomized study of matched cohorts of patients undergoing vacuum-assisted primary fascial closure or polyglactin mesh closure of open abdomens.[42] Although not statistically significant, the authors found that the fistula rate among the V.A.C. cohort was 21% compared with 5% for the mesh group. Rao reported that in 29 patients with EAF managed with a V.A.C., six developed new ECF.[43] Four of these patients died, raising the concern that these complex fistulas may lead to an increased mortality. Fischer described a series of two patients with ECF who achieved fistula resolution, but went on to develop new ECF after management of their open abdominal wounds with a V.A.C. system.[44] Fischer recommended caution with the use of a wound V.A.C. with exposed bowel and that a layer of material be interposed between the V.A.C. sponge and the alimentary tract. Although vacuum therapy remains an attractive management adjunct for the open abdomen, the impact of this modality on the incidence of EAF requires additional investigation.

TREATMENT OF ECF IN TRAUMATICALLY INJURED AND CRITICALLY ILL PATIENTS

The effective management of EAF/ECF is a considerable challenge in posttraumatic care. EAF are associated with a mortality of 36 to 64%, which is markedly higher than current outcomes with more traditional ECF.[26,45 47] Unlike ECF with an intact abdominal wall, which have a spontaneous closure rate of 50 to 80%, EAF require surgical intervention the majority of the time to achieve resolution.[47 50]

The identification of optimal treatment algorithms, particularly in the setting of EAF, remains

elusive. Key components of management include adequate delivery of nutrition, electrolyte/fluid deficit correction, effective control of sepsis and early surgical intervention when possible. For complex or recurrent fistulas, several nonoperative approaches designed to provide for control of fistula output have been proposed. As the character of EAF/ECF can be highly variable among patients, the ability of the trauma/critical care physician to adapt approaches to fit the unique patient scenario is highly beneficial.

Nutrition plays a central role in the effective management of EAF/ECF. The decision of enteral versus parenteral delivery systems, however, remains controversial and is largely dictated by the nature of the fistula and the nutritional status of the patient. Early reports by Deitel and Thomas suggested that patients receiving total parenteral nutrition (TPN) might have twice the ECF closure rate with half of the mortality.[51,52] These initial examinations, however, had significant methodologic flaws that limited the ability of investigators to definitively attribute this improvement over historical controls to the use of TPN alone. The use of TPN has revolutionized the care of the fistula patient by allowing for the delivery of nutrition when enteral routes are not possible, minimizing fistula effluent, and allowing for improved wound care.[53] On the negative side, the delivery of TPN through central venous catheters is associated with an appreciable rate of bacteremia and line sepsis.[54] In one study conducted by Wang and colleagues, they obtained positive blood cultures from 24.6% of 88 catheters utilized to deliver TPN to patients undergoing nonoperative management of enteric fistulas.[55] Enteral nutrition has also been advocated as a potential means of support for patients with EAF/ECF, with recognized benefits including the protection of mucosal integrity and decreased cost relative to TPN. For proximal fistulas, the intubation of the fistula itself has been utilized effectively for delivery of enteral nutrition.[56,57] To date, however, there have been no well-designed studies comparing effectively the impact of TPN versus enteral nutrition for the management of ECF after trauma or in the setting of critical illness.

The role of somatostatin or its analog, octreotide, as an adjunct in the treatment of EAF/ECF has also been proposed. In one randomized, double-blinded, placebo-controlled trial of early octreotide therapy for gastric, small bowel, and pancreatic fistula, Sancho and colleagues found that octreotide failed to reduce fistula output compared with placebo.[58] These investigators also noted that neither the incidence of spontaneous closure nor the mean time to closure was significantly impacted by octreotide use. In a multicenter, randomized trial conducted by Torres and colleagues, researchers found that although octreotide use did not affect the frequency of fistula closure, output and time to closure was decreased in the somatostatin group.[59] To date, however, there is no evidence from controlled trials supporting specifically the use of somatostatin or octreotide for EAF/ECF in trauma or critical illness. For further information on nutrition and the role of octreotide, please refer to Dr. Bleier and Hedrick's article on metabolic support of the ECF patient in this issue.

Nonoperative management requires patience and the development of contingencies for the high rate of failure that can be expected with this approach. In a review of 53 patients undergoing nonoperative management of fistulas from various causes, including trauma, LaBerge and colleagues observed a spontaneous closure rate of only 57%.[60] Most of the observed closures occurred within 2 months. Although this group was unable to identify any difference in spontaneous closure rates based on fistula output, they did find that colonic fistulas were particularly difficult to manage and closed spontaneously in only 10% of patients.

For patients managed nonoperatively, control of fistula output and exclusion from the surrounding field of an open abdomen may improve patient outcomes and facilitate delayed operative intervention. Although covered more in-depth by Drs. Hoedema and Suryadevara in this issue, some points deserve extra emphasis. Currently, several approaches to facilitate effluent control have been advocated. When associated with an intra-abdominal abscess and amenable to the utilization of such approaches, percutaneous interventions may prove useful.[61] Other exclusion and isolation techniques have been employed, including the floating stoma, and the utilization of vacuum-assisted closure approaches.[62–65] The floating stoma involves cutting a trephine over the fistula in a plastic silo covering exposed viscera and suturing the edges of the fistula to the silo.[63] The matured fistula can then be conveniently covered with an ostomy appliance approximated to the plastic silo, effectively controlling the fistula effluent. Particularly in the context of open abdominal wounds, the effective employment of these practices constitutes a significant challenge. By whatever means effective isolation of the fistula can be achieved, the successful accomplishment of this endeavor provides for the healing of the surrounding wound in a field unimpeded by fistula effluent. This healing can be utilized to permit skin grafting of the open abdominal wound and delayed operative treatment for fistulas that do not resolve spontaneously.

The timing and extent of operative intervention for EAF/ECF has not been well studied. Early operative approaches have been advocated, particularly in the setting of the open abdomen, where a window of opportunity prior to the onset of the "frozen abdomen" may exist.[66] Once the development of dense adhesions has occurred, however, initial nonoperative management with planning for delayed surgical intervention for persistent fistula is advisable. The obliterative peritonitis

that develops takes at least 4 months to subside to allow for safe laparotomy and adhesiolysis.[67]

In both the acute and chronic settings, recurrence rates after operative treatment of EAF/ECF are high. In a retrospective study of 205 patients undergoing operative treatment of ECF from various causes, Lynch et al found that 20.5% developed a recurrence within 3 months of intervention.[68] Multivariate analysis by this group demonstrated that ECF recurrence was more likely after oversewing than when resectional approaches were utilized (36% vs 16%, respectively, $p = 0.006$). In a subsequent examination of 135 patients undergoing operative repair of ECF, Brenner and colleagues[28] found that recurrence was more common when resection was performed by stapled anastomosis (35%) than when resection and hand-sewn anastomotic approaches were utilized (11%).[69] This group also noted that a failed operation was a primary determinant of mortality after ECF repair, and that other risk factors for ECF recurrence included the presence of inflammatory bowel disease, small bowel location, and an interval of 36 weeks or longer between diagnosis and operation.

Although the limited literature on the topic support the use of resectional techniques over less-extensive approaches, the role of adjuncts such as fibrin glue and biologic dressing coverage are less well defined.[50,68 74] There are also significant questions regarding the closure of the open abdomen after fistula resection that remain unanswered. Specifically, does the role of closure type affect the rate of refistulization. In a small retrospective study by Connolly and colleagues, the investigators found that achieving primary suture closure of the abdominal wall resulted in no refistulization among 34 patients, whereas abdominal wall reconstruction with prosthetic mesh or porcine collagen mesh was associated with refistulization in 24.1% and 41.7% of patients, respectively.[71] At present, no well-designed studies examining this topic effectively are available.

CONCLUSION

In conclusion, the management of EAF/ECF in trauma and critical illness remains a significant challenge. Well-designed studies of EAF/ECF management do not presently exist. Based on the above review, we recommend prevention of EAF in the patient with an open abdomen requiring TAC. These preventative techniques include coverage of hollow viscera with omentum, avoidance of serosal injury, and closure of fascia or skin as soon as possible. As no definitive answer exists regarding risk of ECF with TAC techniques, the method of TAC should be individualized based on the disease process and the surgeon's familiarity with the technique. Consideration for the possibility of new EAF/ECF arising in the setting of the use of the V.A.C. system should be made. Enteral nutrition should be provided when possible, including in the patient with the open abdomen and in the EAF/ECF patient when not contraindicated. After a period of nonoperative management, the segment of bowel that is the source of the EAF/ECF should be resected when possible, although other minimally invasive techniques such as the use of fibrin glue may be useful when faced with a frozen abdomen. Despite what has been reviewed in this report, many questions remain unanswered about the management of EAF/ECF. An ongoing retrospective study being conducted by the Western Association for the Surgery of Trauma promises to provide some answers with regards to EAF, as does a separate prospective investigation of open abdominal management that is pending from the American Association for the Surgery of Trauma Multicenter Trials Committee. There is, however, a considerable need for additional research on this problematic sequela of care in trauma and critical illness.

DISCLAIMER

The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

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